CLAIMS

What is claimed is:

1. A method of fabricating a ceramic micro-glow plug, the method comprising:

providing a liquid precursor including chemical elements suitable for forming said ceramic;

forming a solid micro-glow plug utilizing said liquid precursor; and

treating said solid micro-glow plug to form an electrically conductive ceramic micro-glow plug.

2. The method of claim 1 wherein forming a solid micro-glow plug comprises:

forming a mold for the electrically conductive ceramic micro-glow plug,

applying said liquid precursor into the mold,

solidifying said liquid precursor in said mold, and

removing the micro-glow plug from said mold.

3. The method of claim 2 wherein said solidifying comprises exposing said molded precursor liquid to ultra-violet light.

4. The method of claim 2 wherein said solidifying comprises heating said precursor liquid.

5. The method of claim 2 wherein said forming a mold comprises forming said mold into a photoresist on a silicon wafer.

6. The method of claim 2 wherein said method further comprises coating said mold with a layer of Teflon™.

7. A method of claim 1 wherein said providing a precursor liquid includes adding a photo-initiator to make said precursor liquid photosensitive.

8. A method of claim 1 wherein said forming comprises spin-coating.

9. The method of claim 1 wherein said forming a solid micro-glow plug comprises a photolithographical patterning process.

10. The method of claim 9 wherein said photolithographical process comprises:

transferring a micro-glow plug design onto a glass mask;

coating said glass mask with a Teflon™ coating;

dispensing said liquid precursor on a substrate;

placing said glass mask in contact with said precursor on substrate spaced at a predetermined height wherein the predetermined height between the substrate and the glass mask determines the thickness of the solid micro-glow plug;

exposing the liquid precursor to ultra-violet light through said mask to solidify the liquid precursor according to the glass mask;

removing the remaining liquid precursor from the substrate; and

removing the solid micro-glow plug from the wafer.

11. The method of claim 1 wherein treating comprises pyrolysis of the solid micro-glow plug at a temperature of 900°C to 1100°C.

12. The method of claim 11 wherein said pyrolysis comprises heating at a temperature of 1000°C.

13. The method of claim 1 wherein said treating comprises annealing the solid micro-glow plug at a temperature of 1300°C to 1500°C.

14. The method of claim 13 wherein said annealing comprised heating at a temperature of 1400°C.

15. The method of claim 1 wherein said chemical elements include silicon, carbon and nitrogen, and said ceramic comprises a silicon carbon-nitride.

16. A micro-glow plug, comprising:

a ceramic heating element having a first arm having a first width, a second arm having a second width, and a tip having a third width that is less than said first and second widths, said first arm and second arm connected to said tip; and

a first connecting apparatus for electrically connecting a voltage source across the first arm and the second arm so that when current is applied to said connecting apparatus a current flows through the ceramic heating element wherein the current density at the tip is increased due to the decreased third width of the tip to generate a high operating temperature at the tip while the first arm and the second arm remain relatively cool.

17. The micro-glow plug of claim 16 wherein said first width and said second width are substantially equal.

18. The micro-glow plug of claim 16 wherein said ceramic heating element comprising a silicon, carbon, and nitrogen composition.

19. The micro-glow plug of claim 18 wherein the ceramic heating element of silicon, carbon, and nitrogen composition further comprises:

Si_x wherein x ranges between 1.0 and 4.0;

C_y wherein y ranges between 1.1 and 3.0; and

N_z, wherein z ranges between 0.0 and 4.0.

20. The micro-glow plug of claim 18 wherein said ceramic heating element further comprises a metallic element.

21. The micro-glow plug of claim 19 wherein the atom concentration of said metallic element falls within a range of 0.0 to 2.0 for every silicon atom.

22. The micro-glow plug of claim 20 wherein said metallic element comprises boron.

23. The micro-glow plug of claim 20 wherein said metallic element comprises aluminum.

24. The micro-glow plug of claim 18, and further comprising phosphorous, wherein the atom concentration of the phosphorous falls within a range of 0.0 to 2.0 for every silicon atom.

25. The micro-glow plug of claim 16, further comprising an oxide coating to protect the ceramic heating element from corrosion.

26. The micro-glow plug of claim 16, further comprising:

a body having a first end and a second end;

two or more ceramic heating elements integrally connected to said first end of said body, said first arm of the two or more micro-glow plugs interconnected; and wherein:

said connecting apparatus comprises a switching voltage source and a switch apparatus for electrically connecting said switching voltage source across said interconnected first arm of the two or more ceramic heating elements and each second arm of said two or more ceramic heating elements so that a current flows through a first one of said two or more ceramic heating elements and said switching voltage source switches voltage to the next second arm of the next one of said two or more ceramic heating elements when said first one of said two or more ceramic heating elements fails.

27. The micro-glow plug of claim 26 wherein said body is cylindrical.

28. A micro-glow plug system comprising:

a body having two or more micro-glow plugs integrally connected to the body;

a switching apparatus for switching power between said two or more micro-glow plugs;

a sensor to monitor a current flow to said two or more micro-glow plugs wherein when said current flow falls below a predetermined level, said sensor sends a signal to said switching apparatus and said switching apparatus switches said power to a next one of said two or more micro-glow plugs.

29. The micro-glow plug system of claim 28, and further including a source of said power, and wherein said sensor is connected in serial between the switching apparatus and said power source.

30. The micro-glow plug system of claim 28 wherein said switching apparatus comprises a plurality of controlled switches each having a control terminal and a controller for switching said power to the control terminal of a corresponding one of said plurality of controlled switches.

31. A micro-glow plug made from a single ceramic material in which the largest dimension is 2 mm or less, and with a glow tip of a size 0.2 mm or less.

32. The micro-glow plug of claim 31 made of a material comprising silicon, carbon and nitrogen.

33. The micro-glow plug of claim 32 coated with an oxide coating to protect it from corrosion.

34. The micro-glow plug of claim 32 wherein said material is described by the composition $Si_xC_yN_z$, where x, y and z fall in the following ranges: x=1 to 4; y=1.1 to 3.0;and z=0 to 4.

35. The micro-glow plug of claim 34 wherein said material further comprises a metallic element.

36. The micro-glow plug of claim 35 wherein the atom concentration of said metallic element falls within a range of 0.0 to 2.0 for every silicon atom.

37. The micro-glow plug of claim 35 wherein said metallic element comprises boron.

38. The micro-glow plug of claim 35 wherein said metallic element comprises aluminum.

39. The micro-glow plug of claim 34, and further comprising phosphorous, wherein the atom concentration of the phosphorous falls within a range of 0.0 to 2.0 for every silicon atom.

40. The micro-glow plug of claim 31 coated with an oxide coating to protect it from corrosion.

41. The micro-glow plug of claim 31 wherein said glow tip reaches a temperature of from 1200°C to 1600°C for ignition.

42. The micro-glow plug of claim 31 wherein said glow tip is capable of reaching a temperature of 1500°C.

43. The micro-glow plug of claim 31 that uses 5.0 watts of power or less to reach and maintain its highest operating temperature.

44. The micro-glow plug of claim 31 that uses 1.0 watt of power or less to reach and maintain its highest operating temperature.

45. The micro-glow plug of claim 31 that reaches its glow temperature in one-half of a second or less from a cold start.

46. A micro-glow plug that reaches its glow temperature in one-half of a second or less from a cold start.

47. A micro-glow plug having a glow tip, a current carrying section for carrying current to said glow tip, a glow tip, and a plurality of contact pads for connecting to an electrical circuit, said glow tip having an electrical resistance of ten times or more as compared to said current carrying section.

48. A system of micro-glow plugs (MPS) comprising an array of micro-glow plugs connected on a single supporting device.

49. The system of claim 48 wherein the total number of micro-glow plugs in said MPS range from two to one thousand.

50. The system of claim 48, and further including an electrical circuit that switches the operation of said MPS from one of said micro-glows plug to the next until all of said micro-glow plugs in said MPS are exhausted.

51. The system of claim 48, and further including a circuit for producing an electrical signal providing information on the remaining expected life of said MPS.